- *Infections*. PEM increases susceptibility to many common infectious diseases. Conversely, infections have a negative effect on nutrition, thus establishing a vicious cycle.
- *Acute and chronic illnesses*. The basal metabolic rate becomes accelerated in many illnesses resulting in increased daily requirements for all nutrients. Failure to recognize these nutritional needs may delay recovery. PEM is often present in patients with wasting diseases, such as *advanced cancers* and *AIDS* (discussed later).
- *Chronic alcoholism*. Alcoholic persons may sometimes suffer PEM but more frequently have deficiencies of vitamins, especially thiamine, pyridoxine, folate, and vitamin A, as a result of poor diet, defective gastrointestinal absorption, abnormal nutrient utilization and storage, increased metabolic needs, and an increased rate of loss. A failure to recognize the likelihood of thiamine deficiency in persons with chronic alcoholism may result in irreversible brain damage (e.g., *Wernicke encephalopathy* and *Korsakoff psychosis*, discussed in Chapter 28).
- *Ignorance and failure of diet supplementation.* Even the affluent may fail to recognize that infants, adolescents, and pregnant women have increased nutritional needs. Ignorance about the nutritional content of various foods is also a contributing factor. Some examples are: iron deficiency in infants fed exclusively artificial milk diets; polished rice used as the mainstay of a diet may lack adequate amounts of thiamine; lack of iodine from food and water in regions removed from the oceans, unless supplementation is provided.
- *Self-imposed dietary restriction. Anorexia nervosa, bulimia*, and less overt eating disorders affect many individuals who are concerned about body image and are obsessed with body weight (anorexia and bulimia are discussed later).
- *Other causes.* Additional causes of malnutrition include gastrointestinal diseases and malabsorption syndromes, genetic diseases, specific drug therapies (which block uptake or utilization of particular nutrients), and inadequate total parenteral nutrition.

Protein-Energy Malnutrition

Severe PEM is a serious, often lethal disease that preferentially affects children. It is common in low-income countries, where it affects up to 30% of children and is a major factor in high death rates among children younger than 5 years of age. It is estimated that malnutrition is responsible for approximately 50% of deaths in infancy and childhood each year in developing countries. In developed countries, PEM often occurs in older and debilitated patients in nursing homes and hospitals, but also occurs with disturbing frequency in children living in poverty, even in the United States.

Malnutrition is determined according to the *body mass index* (BMI, weight in kilograms divided by height in meters squared). A BMI less than 16 kg/m^2 is considered malnutrition (normal range 18.5 to 25 kg/m^2). In more practical ways, a child whose weight falls to less than 80% of normal (provided in standard tables) is considered malnourished. However, loss of weight may be masked by generalized edema, as discussed later. Other helpful parameters are the evaluation of fat stores (thickness of skin folds), muscle mass (reduced circumference of mid-arm), and serum proteins (albumin and transferrin levels provide a measure of the adequacy of the visceral protein compartment).

Marasmus and Kwashiorkor. In malnourished children, PEM presents as a range of clinical syndromes, all characterized by a dietary intake of protein and calories inadequate to meet the body's needs. The two ends of the spectrum of PEM syndromes are known as *marasmus* and *kwashiorkor*. From a functional standpoint, there are two differentially regulated protein compartments in the body: the somatic compartment, represented by proteins in skeletal muscles, and the visceral compartment, represented by protein stores in the visceral organs, primarily the liver. As we shall see, the somatic compartment is affected more severely in marasmus, and the visceral compartment is depleted more severely in kwashiorkor.

A child is considered to have *marasmus* when weight falls to 60% of normal for sex, height, and age. A marasmic child suffers growth retardation and loss of muscle, the latter resulting from catabolism and depletion of the somatic protein compartment. This seems to be an adaptive response that provides the body with amino acids as a source of energy. The visceral protein compartment, which is presumably more precious and critical for survival, is only marginally depleted, and hence serum albumin levels are either normal or only slightly reduced. In addition to muscle proteins, subcutaneous fat is also mobilized and used as fuel. The production of leptin (discussed later) is low, which may stimulate the hypothalamic-pituitary-adrenal axis to produce high levels of cortisol that contribute to lipolysis. With such losses of muscle and subcutaneous fat, the *extremities are emaciated*; by comparison, the head appears too large for the body (Fig. 9-22*A*). Anemia and manifestations of multiple vitamin deficiencies are present, and there is evidence of *immune deficiency*, particularly T-cell–mediated immunity. Hence, concurrent infections are usually present, which impose additional nutritional demands. Unfortunately, images of children dead or near death with marasmus, have become commonplace in television and newspaper reports of famine and disasters in various areas of the world.

Kwashiorkor occurs when protein deprivation is relatively more severe than the deficit in total calories (Fig. 9-22*B*). This is the most common form of PEM seen in African children who have been weaned too early and subsequently fed, almost exclusively, a carbohydrate diet (kwashiorkor, from the Ga language in Ghana, describes a disease in an young child that occurs following the arrival or another baby). The prevalence of kwashiorkor is also high in impoverished countries of Southeast Asia. Less severe forms may occur worldwide in persons with chronic diarrheal states in which protein is not absorbed or in those with chronic protein loss due to conditions such as protein-losing enteropathies, the nephrotic syndrome, or after extensive burns. Cases of kwashiorkor resulting from fad diets or replacement of milk by rice-based beverages have been reported in the United States.

In kwashiorkor, marked protein deprivation is associated with severe depletion of the visceral protein compartment, and the resultant hypoalbuminemia gives rise to